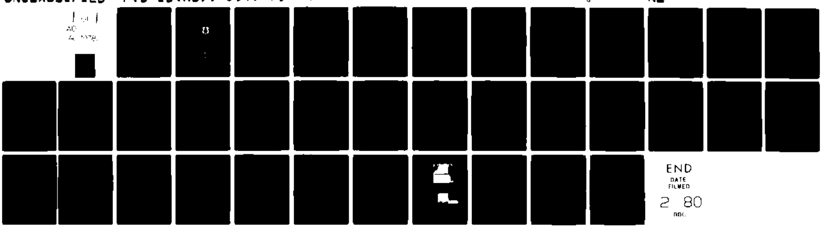
AD-A079 782 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH F/G 8/2
GEODETIC JOURNAL (SELECTED ARTICLES),(U)
AUG 79 N FRANCULA, M DORDEVIC
UNCLASSIFIED FTD-ID(RS)T-0947-79 NL



END
DATE
FILMED
2 80
DDC

PHOTOGRAPH THIS SHEET

ADA079782

DTIC ACCESSION NUMBER

LEVEL

INVENTORY

1

FTD-ID(RS)T-0947-79

DOCUMENT IDENTIFICATION

This document has been approved for public release and sale; its distribution is unlimited.

DISTRIBUTION STATEMENT

ACCESSION FOR		
NTIS GRA&I	☑	
DTIC TAB	☐	
UNANNOUNCED	☐	
JUSTIFICATION		
BY		
DISTRIBUTION /		
AVAILABILITY CODES		
DIST	AVAIL AND/OR SPECIAL	
A		

DISTRIBUTION STAMP

DDC
RECEIVED
JAN 24 1980
E

DATE ACCESSIONED

79 12 27 353

DATE RECEIVED IN DTIC

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDA-2

DTIC FORM OCT 79 70A

DOCUMENT PROCESSING SHEET

FTD-ID(RS)T-0947-79

FOREIGN TECHNOLOGY DIVISION

GEODETIC JOURNAL
(SELECTED ARTICLES)

EDITED TRANSLATION

FTD-ID(RS)T-0947-79 2 August 1979

MICROFICHE NR: FTD-79-C-001032

GEODETIC JOURNAL (SELECTED ARTICLES)

English pages: 32

Source: Geodetski List, Vol. 32(55), Nr. 1-3, 1978, 5-17; 23-30

Country of Origin: Yugoslavia
Translated by: SCITRAN
F33657-78-D-0619
Requester: DMMAC/SDDLL
Approved for public release; distribution unlimited.

PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

Table of Contents

USE OF COMPUTERS IN THE TEACHING OF CARTOGRAPHY

by

Nedjeljko Frančula, Zagreb*

1. INTRODUCTION

The Computer Center at the University of Zagreb was implemented on 29 June 1972. A self-management agreement between the Organization for Financing of Goal-Oriented Education, Council for Scientific Work, University of Zagreb, and University Computer Center ensured since 1973 the resources to the faculties for the use of University Computer Center (SRCE) in teaching.

The course in electronic computers and programming having been introduced into the teaching plan of the Geodesy faculty during the academic year 1970/1971, it was starting in early 1973 that practical use of this training could be implemented using SRCE computers. At the same time, the possibility was created for using training in data processing also in other subjects where this might be required or necessary by either partial or total help by computers. In the teaching of cartography this possibility was taken advantage of already in the summer semester of the 1972/1973 school year.

The University Computer Center has today at its disposal a UNIVAC 1110 computer system. The operative memory of the computer consists of two parts, namely a memory with magnetic tape having 96 K words per 36 bytes and memories with ferrite cores at 262K words per 36 bytes. The input-output units attached to the computer include two card-readers, two fast stampers, card-borer, and paper-tape borer. The massive memory is provided by two magnetic disk units and five units each of 7- and 9-channel magnetic tapes.

---

*Address of author: Assistant professor Dr. Nedjeljko Frančula, Geodesy Department, Kačićeva 26, Zagreb, Yugoslavia.

Unfortunately, the Computer Center does not have enclosures to this day. The Geodesy Department has neither a terminal connection with the Computer Center nor does it have a computer in residence.

2. USE OF COMPUTERS IN THE TEACHING OF MATHEMATICAL CARTOGRAPHY

In practical applications of mathematical cartography, the students are to construct a mathematical base for the mapping of a specific part of Earth's surface. They have to calculate rectangular coordinates of the crossections of a network of meridians and parallel lines (longitudes and latitudes), map the crosssection points, plot the network, and draw into the network the contours of the region studied. Because of this one must also calculate the deformations at all points of the cross-section of the meridian and parallel lines network.

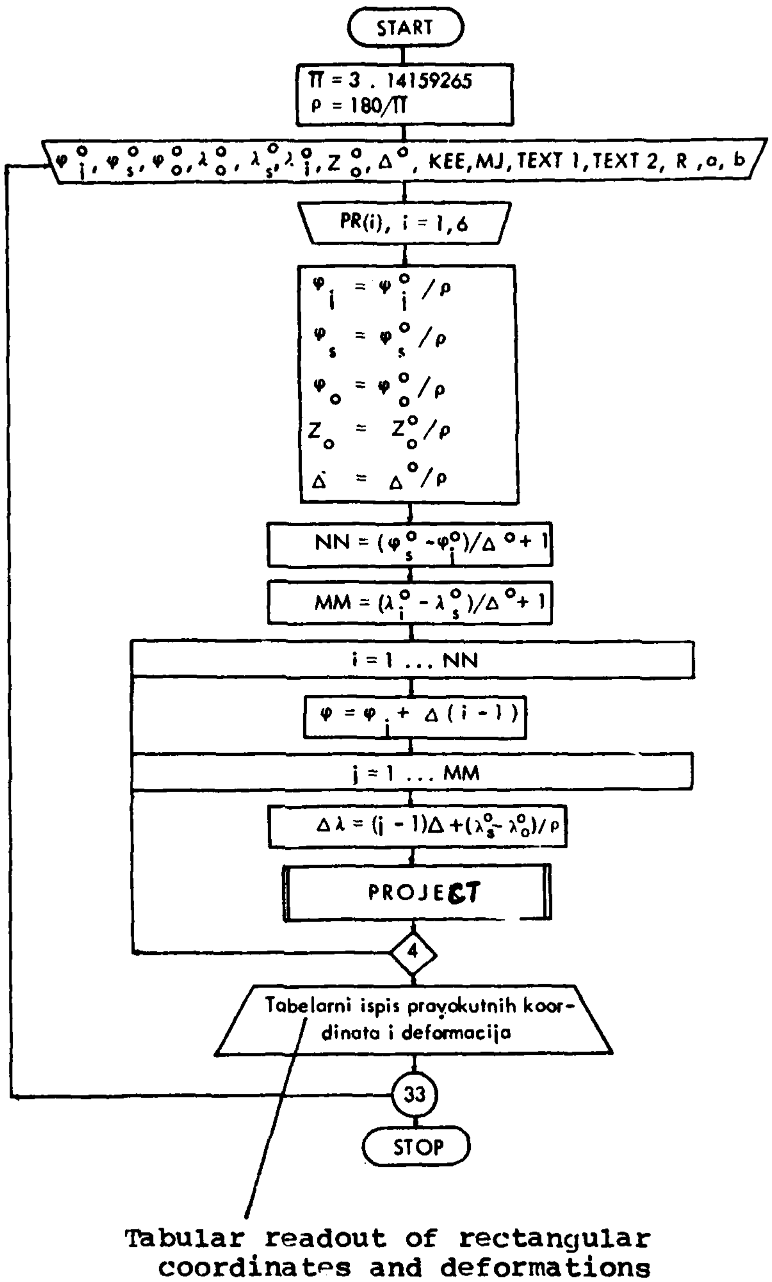


Fig. 1. Flow diagram of the principal program (KARPRO) for the calculation of rectangular coordinates and deformations in cartographic projections.

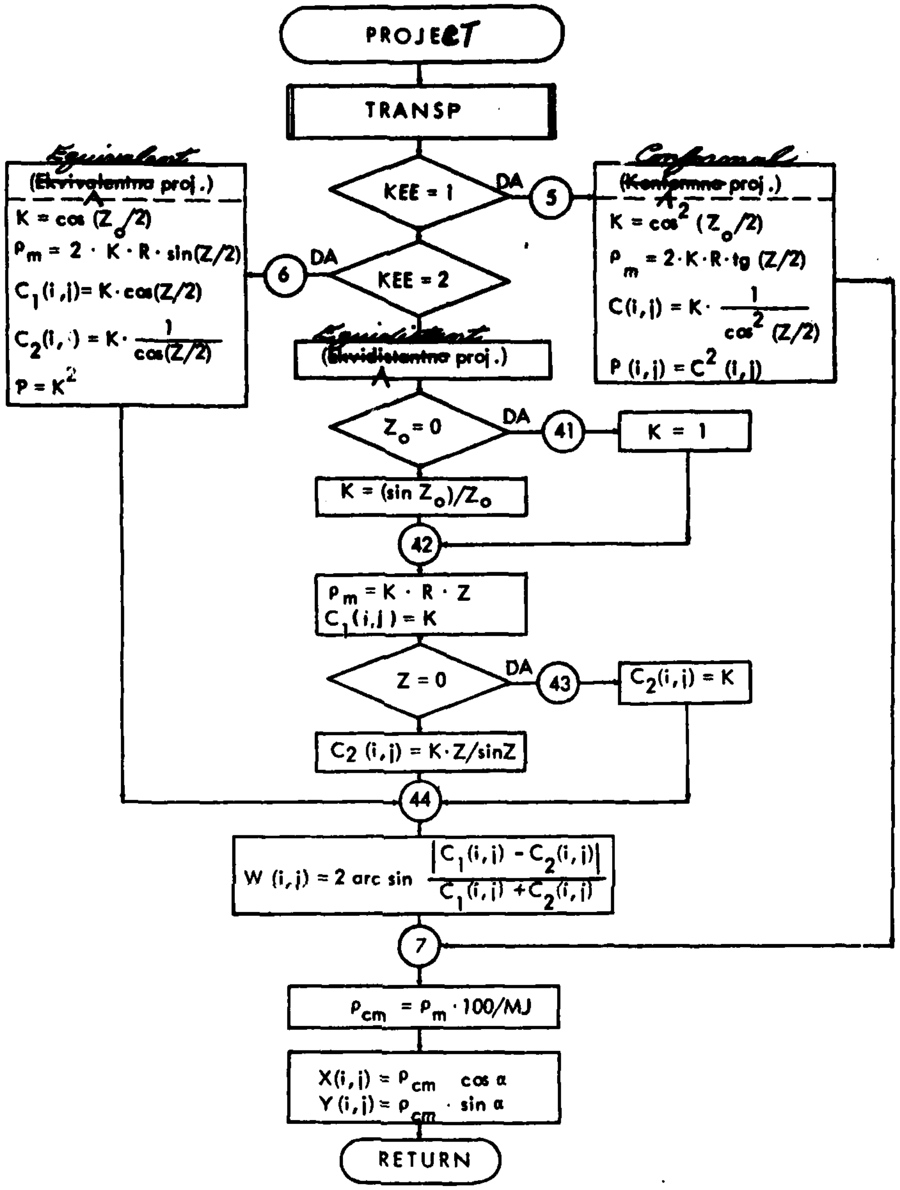


Fig. 2. Flow diagram of the sub-programming for the calculation of rectangular coordinates and deformations in azimuthal projections.

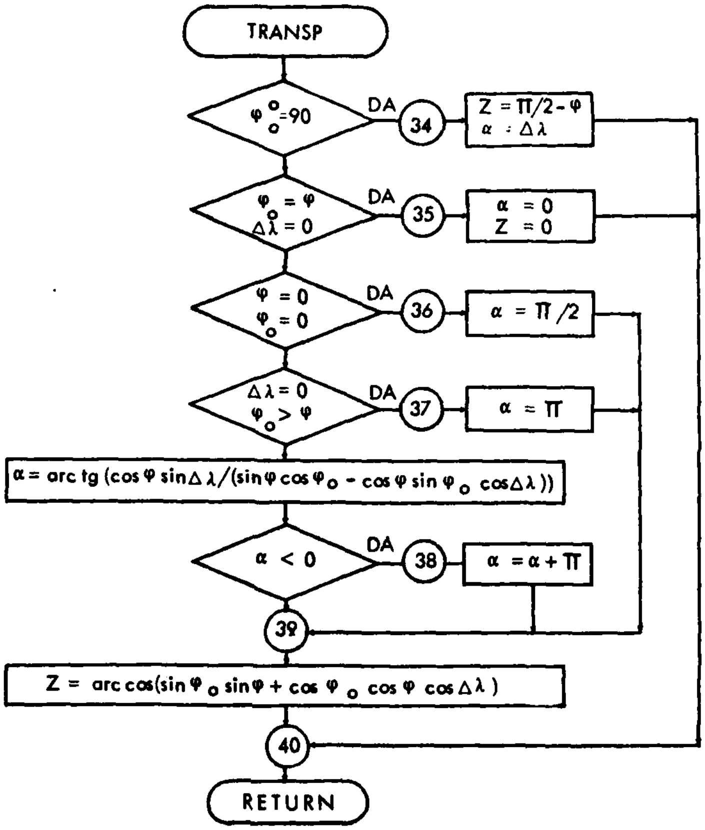


Fig. 3. Flow diagram of sub-programming for the determination of polar coordinates Z and α from geographic coordinates φ and λ.

Prior to the introduction of computers into teaching practice, most of the data were processed by vertical conical projections and in the Bonne projection.

For teaching requirements in this field the author of this article compiled a computer program for the calculation of rectangular coordinates and deformations in cartographic projections. The

program is effected by the principal program KARPRO and subprograms PROJEK and TRANSP. In the principal program (Figure 1) are considered all the required data, determined are geographical coordinates φ, λ for all points of the cartographic network, and at the end the rectangular coordinates and deformations are read out in tabular form (Figure 4). PROJEK is subprogram in which rectangular coordinates are calculated as well as the concomitant deformations in individual projections or specific groups of projections, such as, for instance, azimuthal projections (Figure 2). Subprogram TRANSP is used to determine polar coordinates Z and α from geographic coordinates φ, λ and coordinates of the poles of the normal cartographic network φ_0, λ_0. This subprogram is used to establish a relationship between vertical, transverse, and oblique projections.

Note that besides the subprogram for azimuthal projections, there are developed as of the present time and implemented into teaching use both the subprograms for Bonne and for conformal conical projections. Just how these programs are being used in teaching shall be shown on the example of azimuthal projections. Subprograms for other than here mentioned projections and projection groups are being developed. The subprogram for azimuthal projections (Figure 2) includes conformal, equidistant, and equivalent projections, and within each of these groups also vertical, transverse, and oblique projections.

Each student is given the problem of calculating the mathematical base for the mapping of one of the continents in some azimuthal projection. In the exercises, the calculations are first done by using the usual aids, such as tables and pocket calculators without possibility of programming. Then the flow diagram for computer calculations (Figs. 1, 2, 3) is worked out. Special attention is given to the development of this flow diagram.

The applicability of existing formulas for computer calculations is examined and all the necessary input information is assembled. This includes the southern boundary parallel line (φ_j), the northern boundary parallel line (φ_s), the central meridian (λ_s), the eastern boundary meridian (λ_i), the pole coordinates of the normal cartographic network (φ_o, λ_o), the interval between two adjacent meridians and parallel lines (Δ), the zenithal distance of a small circle around which there is no deformation (Z_o), the number for a series of projections (K[illegible]E: 1-conformal, 2-equivalent, 3-equidistant), measurement ([illegible]j), sphere radius (R), and the text part which is read out at the head of the output list (TEXT 1 - type of projection, e.g. EQUIVALENT AZIMUTHAL; TEXT 2 - mapping domain, e.g. ASIA).* Then every step in the flow diagram (chart) is analyzed and explained. Following the flow diagram, the program in FORTRAN is worked out. Each student is given the output list (Figure 4) for his (hers) problem on the basis of which to map and draw the cartographic network. Besides rectangular coordinates y, x, the output list lists also the values of extreme measurements of lengths C1 and C2 and maximal angular deformations W.

Using conventional calculators the student must then calculate rectangular coordinates and deformations for two parallel lines, i.e. around 10-15 points.

By such use of computers in teaching we accomplished the following:

1) The student familiarizes himself (herself) with the use of computers and works out mathematical bases for geographical mapping.

---

*If in some projections the Earth is considered as being an ellipsoid, then instead of sphere radius R the large and the small semi-axis of the ellipsoid a and b are given. Additional parameters are placed in PR (i).

2) While calculating the mathematical base for the mapping of the continent one must first calculate the rectangular coordinates and deformations at around 80-100 points. The calculation at all these points of the network is identical and therefore also accordingly tedious and time-consuming. By using the computer we acquired the mathematical base for the construction of the cartographic network of the entire map, and we also liberated the students from tedious calculating. The calculation of rectangular coordinates and deformations at 10-15 points is enough for the student to be shown the calculation technique without the use of a computer.

EQUIVALENT AZIMUTHAL PROJECTION
EUROPE
RECTANGULAR COORDINATES, MEASUREMENTS AND DEFORMATIONS
FJ= 30 FS= 75 FO= 60 LO= 10 D= 5 MJ=1/ 21500000.

		0	5	10	15	20	25	30
	Y =	,000	2,319	4,626	6,911	9,160	11,364	13,509
30	X =	-15,354	-15,273	-15,031	-14,626	-14,064	-13,342	-12,464
	C1=	,966	,965	,964	,962	,959	,955	,951
	C2=	1,035	1,036	1,037	1,039	1,043	1,047	1,052
	W =	3,972	4,022	4,174	4,426	4,779	5,230	5,780
	Y =	,000	2,170	4,329	6,465	8,568	10,626	12,627
35	X =	-12,842	-12,763	-12,533	-12,150	-11,616	-10,931	-10,099
	C1=	,976	,976	,975	,973	,970	,966	,962
	C2=	1,024	1,025	1,026	1,028	1,031	1,035	1,039
	W =	2,749	2,796	2,936	3,170	3,496	3,913	4,421
	Y =	,000	2,012	4,013	5,992	7,939	9,843	11,692
40	X =	-10,302	-10,229	-10,013	-9,653	-9,151	-8,509	-7,727
	C1=	,985	,984	,983	,981	,979	,976	,972
	C2=	1,015	1,016	1,017	1,019	1,022	1,025	1,029
	W =	1,754	1,797	1,926	2,141	2,440	2,824	3,290

Fig. 4. A part of the output list of KARPRO program.

Within the framework of mathematical cartography the Gauss-Krueger projection is also studied in more detail. In their exercises the students work out the following data in Gauss-Krüger projection::
calculation of rectangular coordinates x, y from geographic coordinates φ, λ calculation of geographic coordinates φ, λ from

rectangular coordinates x, y and transformation of coordinates between the neighboring coordinate compositions. Computer programs have been set up for all three sets of problems /1/, /3/.

Prior to the implementation of computers in teaching the students accumulated each of the cited data two ways. One by formulas suitable for calculation by the computer, and the other by formulas suitable for logarithmic computation. Since the first two sets of problems of the corresponding table exist only in logarithmic form, the calculation in both ways here was logarithmic. Upon the implementation of computers in teaching during 1973, the logarithmic method for calculation is missing in its entirety, having been replaced by computer calculation. The students now calculate each set of problems by only one way, namely with the help of tables and pocket calculators. For the exercises, a flow diagram for computer calculation (see /3/) is worked out and analyzed. The results of their calculations the students compare and control by data calculated by the computer.

3. THE USE OF COMPUTERS IN TEACHING AS A BASE FOR AUTOMATIZATION IN CARTOGRAPHY*

Since 1974 during the framework of the teaching of cartography the students are also lectured on fundamentals of automatization in cartography /4/. Since neither SRCE nor the Department to this day have a plotter or a digitalizer, only a computer can be used for the exercises. Because of this, the possibilities of automatization in cartography are demonstrated to the students in the development

*The use of computers in mathematical cartography is also a part of automatization in cartography, however in this article we treated it separately since we were the first to implement this simplest form of automatization in teaching.

of computer thematic mapping.

The term computer thematic map or briefly computer map are called in which a certain theme is treated by the computer and where the cartographic survey is done by the output unit of the fast printer. For cartographic survey can serve all the signs (26 letters of the English alphabet, numbers, and special signs) present on fast printers as well as signs which are obtained by multiple printing of the given signs one on top of the other. The idea of such a way to prepare thematic maps reached fertile soil, since the traditional methods of preparing thematic maps are frequently too controversial and costly. Besides this, the numerical statistical data which are collected by statistical establishments of individual countries are nowadays processessed almost exclusively by computers, as a result of which the preparation of computer maps comes by itself inasmuch as all the data are present on carriers suitable for computer treatment. The many prepared atlases of computer maps are the best demonstration of the acceptance of such maps and the requirements for them.

Thematic maps of various types can be prepared by the use of computers. Here, thematic maps prepared by the cartogram method are the most frequently encountered. These are thematic maps in which the propagation of certain phenomena or states is shown by the same graphical signs (symbols) within a single territorial unit.

For the preparation of thematic maps by the cartogram method the Cartography Institute of the Geodesy Department in 1974 developed its own program called KOKART (COmputer MAPs) /2/. KOKART is written in the FORTRAN program language. The program requires approximately 50K words of memory, emables fourfold printing of sign over sign, and the magnitude of the map is limited to a single page of the computer paper. Statistical data can be classified into 2-10 classes

by means of seven methods of determining the boundaries of these classes. Thus, by once going through the computer one can obtain - with the same statistical data - 63 variants of the same map.

This program is used in teaching in the following way. During the exercises the functioning principle of the program based on the flow diagram (see /4/) is explained. Then students then perform the exercises in preparing all the necessary data for the production of the map with the help of KOKART programming.

3.1. Preparation of data for the production of computer thematic maps

The data necessary for the production of computer maps consist of a"packet" of coordinates of the boundaries with numbers for territorial units and a"packet" of statistical data. The coordinates of the boundaries are obtained in the following way. On the map of the boundaries of territorial units for which statistical data are given (for instance, the map of census circles, map of political districts, etc.) is applied a network of the rectangle of the magnitude of computer letters including also the white area around the letters which measure 1/10x1/6 inch (2.54x4.23 mm) in size. In their exercises, the students generalize the boundaries, i.e. they approximate them to the boundaries of the rectangle network striving to preserve the shape and the magnitude of territorial units. Considering the rectangle network as a two-dimensional field, the boundaries are coded according to the orders recording order, starting and finishing column, and number of territorial unit. By punching the tickets one can also obtain the packet of boundary coordinates with numbers of territorial units. The packet of statistical data consists of the title of the map, statistical data, and ticket with the data to which the number of territorial units is assigned, class number, and method of class determination.

3.2. Determination of class boundaries

Out of seven methods for class boundary determination in which statistical data are classified, in six of these methods the boundaries are determined automatically by programming. The following are these six methods: Equal intervals, arithmetic progression, geometric progression, reciprocal progression, quantals, and quantals with respect to arithmetic mean. The user can determine the boundaries also in some other way.

In the equal intervals method the range between the minimal and the maximal values is divided into equal intervals. The arithmetic, geometric , and reciprocal progression method is used to determine the class boundaries in such a way that the magnitudes of the classes form corresponding progressions. The geometric progression method cannot be used if some data is negative or equal to zero. The method in which statistical data are arranged by magnitude, parts, or classes in such a way that an equal number of units is present in each class is called the quantal method. In the determination of the class boundaries by the sixth method, statistical data are also arranged by magnitude, however the arithmetic mean of all the values also is determined. Then the quantàl method is applied to the values between the minimal values and the arithmetic mean and the arithmetic mean and the maximal values. This method is employed only for the pair number of the classes.

3.3. Selection of the most suitable method for the determination of class boundaries

Determination of class boundaries is one of the most important tasks in the development of thematic maps. The number of classes and their magnitude are essential also for the visual impression of

of the map and for its expressive value. Although the principles of determination of the classes in thematic cartography are specific and clear, the analysis of many thematic maps indicates that the boundaries of the classes are randomly determined, without any explanation how one arrived at that. The use of computers offers to the author of thematic maps the possibility to rapidly produce a large number of maps with boundaries determined by various methods. This facilitates the study of spatial arrangement of the state or the phenomenon which is shown on the map, and besides this it also makes possible a more objective way for class determination. By making use of histograms produced by computers (Fig. 5) one can confirm whether or not natural class boundaries are present, as determined by the largest "jumps" in the histogram. Besides this, the computers make it possible to compare the various methods of class boundary determination without difficulty and with the aid of specific statistical magnitudes. Thus, Jenks and Coulson /5/ proposed a method of comparison using a coefficient analogous to the variability coefficient. The procedure is as follows: The class boundaries are determined by various methods and all the data are arranged into classes. For each class of each method the proposed coefficient is calculated and for each method the coefficients of all classes are collected. The method in which the summary coefficient is the smallest is therefore the best for the criterion. For the selection of the most suitable method using this criterion the TESTIR (TESTING of the method) programming is prepared using FORTRAN. This program, just like KOKART, includes seven methods for class boundary determinations, whereas the data can be classified into 2-10 classes. If no value falls into any given class, then instead of the calculated summary coefficient one obtains the readout message.

EXISTS EMPTY CLASS.

3.4. Computer thematic maps produced during exercises

The first thematic maps produced by KOKART were the maps of dense population density of Croatian SR according to number of inhabitants per km^2 in administrative communities (townships).

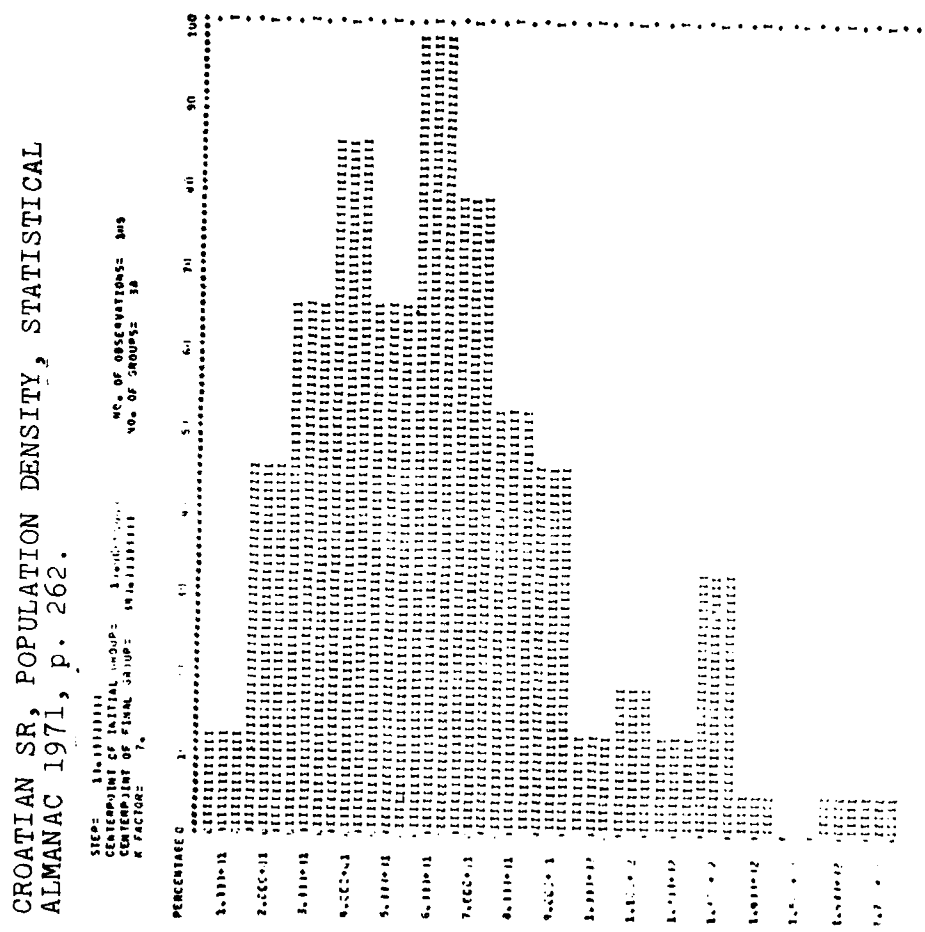
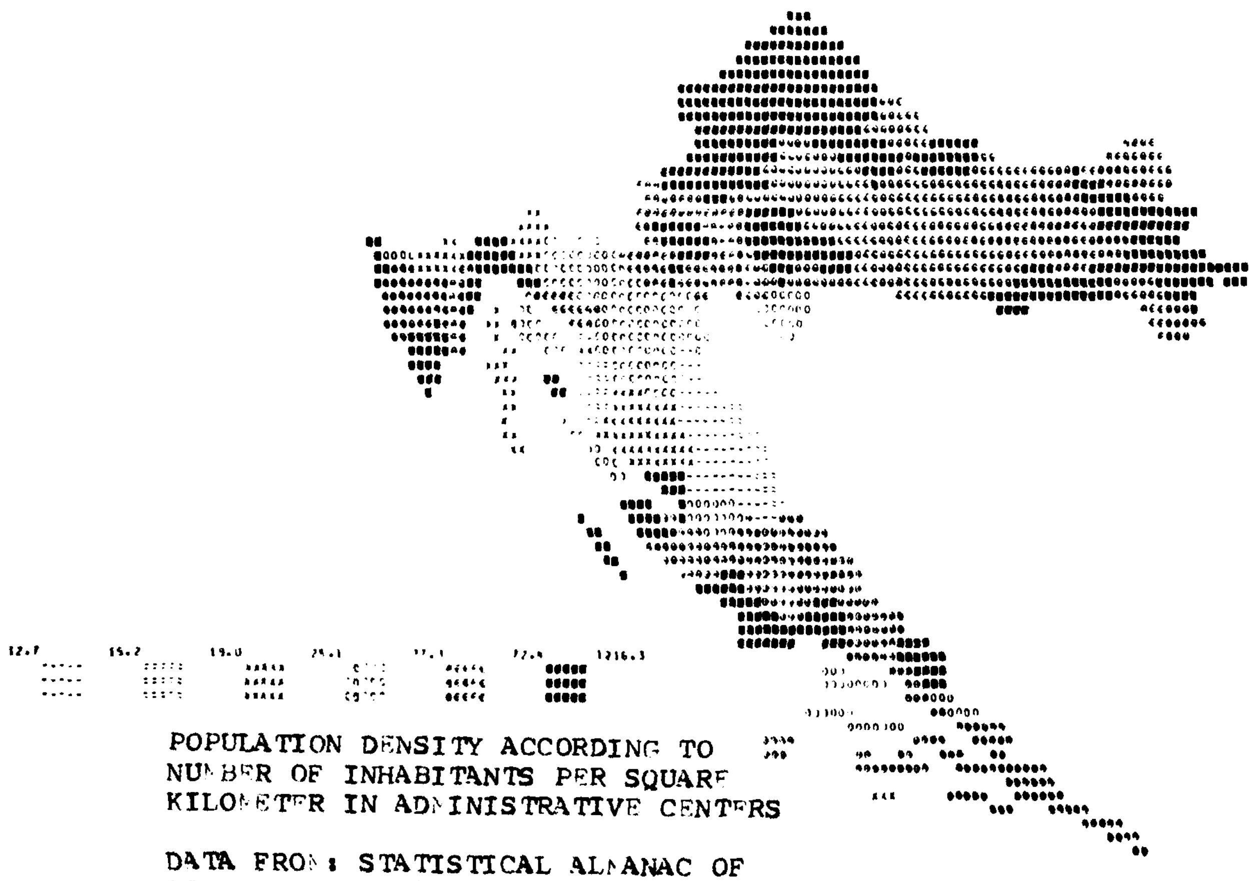


Fig. 5. A part of the histogram produced by HIST subprogram

Used are the census data from 1971 as published in the Statistical almanac of the Croatian SR. Two of these maps are presented (Figs. 6 and 7). On the first of these maps (Fig. 6) the class boundaries

have been determined by the reciprocal progression method. The class boundaries on the second map (Fig. 7) are obtained by the analysis of several histograms produced by the HIST subprogram from UNIVAC statistical library /6/. A part of these histograms is shown in Fig. 5. A comparison - using the Jenks and Coulson method - of these two methods with the remaining five is done using the TESTIR program. The data obtained for six classes are shown in Fig. 8. The smallest obtained coefficient of the boundaries considered shows that the boundaries are well determined by means of histogram analysis.



POPULATION DENSITY ACCORDING TO NUMBER OF INHABITANTS PER SQUARE KILOMETER IN ADMINISTRATIVE CENTERS

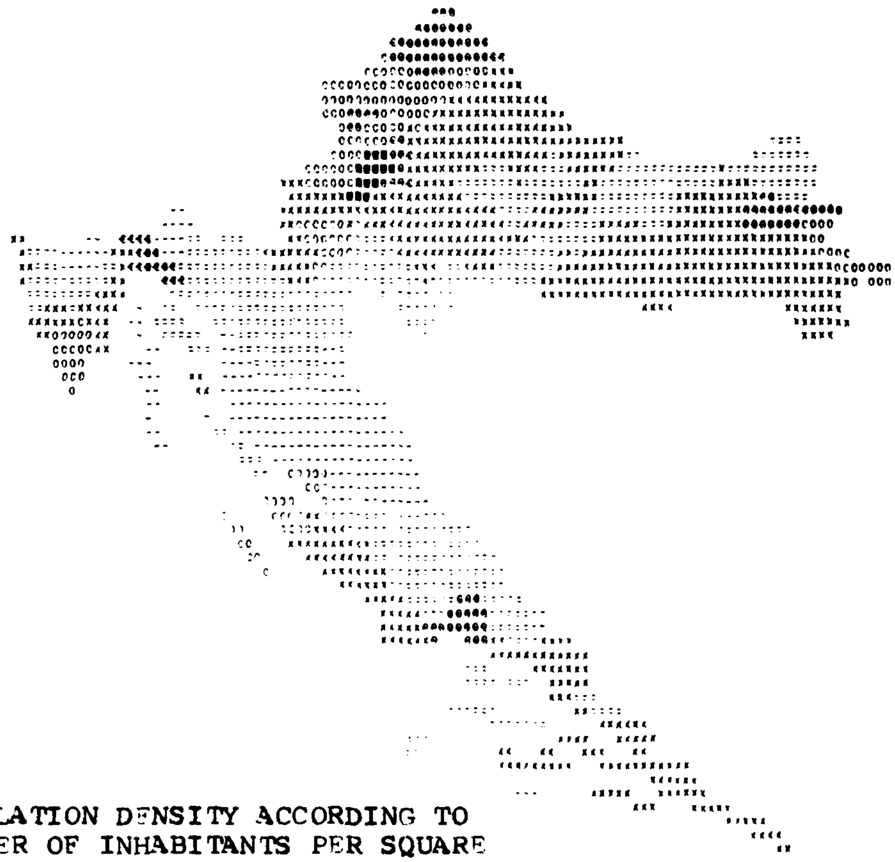
DATA FROM: STATISTICAL ALMANAC OF CROATIAN SR, 1971, p. 262

CLASS BOUNDARIES ARE DETERMINED BY RECIPROCAL PROGRESSION METHOD

Figure 6.

Eight maps of Croatian SR have so far been produced in practical exercises, as well as population density maps of the world according to the number of inhabitants per km^2 in individual countries.

By virtue of the above-described use of computers in teaching the automatization bases in cartography we acquainted the students with certain possibilities which the computer offers to the author of thematic maps. However, for contemporary teaching in this field, a digitalizer, optical indicator (screen), and plotter (see /4/) are also needed.



POPULATION DENSITY ACCORDING TO
NUMBER OF INHABITANTS PER SQUARE
KILOMETER IN ADMINISTRATIVE CENTERS

DATA FROM: STATISTICAL ALMANAC OF
CROSTIAN SR 1971, p. 262

CLASS BOUNDARIES ARE CONSIDERED

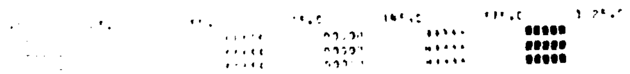


Figure 7.

```
NUMBER OF CLASSES: 6

EQUAL INTERVALS
EXISTS EMPTY CLASS
     12,700    213,300    413,900    614,500    815,100   1015,700   1216,300
ARITHMETIC PROGRESSION
EXISTS VACANT CLASS

     12,700     70,014    184,643    356,586    585,843    872,419   1216,300

GEOMETRIC PROGRESSION
 KOV=   ,722
     12,700     27,165     58,105    124,286    265,845    568,636   1216,300

RECIPROCAL PROGRESSION
 KOV=  5,947
     12,700     15,208     18,951     25,138     37,321     72,419   1216,300

QUANTALS

 KOV=  3,330
     12,700     32,200     49,000     63,200     78,200    110,300   1216,300


QUANTALS WITH RESPECT TO ARITHMETIC MEAN
 KOV=  1,928
     12,700     40,500     60,200     82,813    100,200    134,400   1216,300

BOUNDARIES CONSIDERED

 KOV=   ,606
     10,000     25,000     55,000     95,000    145,000    375,000   1220,000
```

Fig. 8. Output sheet of TESTIR program

REFERENCES

[1] Frančula, N.: Direktna transformacija koordinata pomoću elektroničkih računala između susjednih koordinatnih sustava Gauss-Krügerove projekcije. Geodetski list 1973, 10—12, str. 211—216.

[2] Frančula, N.: KOKART — Program za izradu kompjutorskih tematskih karata. Simpozij Kompjutor na Sveučilištu, Sveučilišni računski centar Zagreb 1974, str. C4/1—7.

[3] Frančula, N.: Računanje elektroničkim računalima. U: B. Borčić-Gauss-Krügerova projekcija meridijanskih zona, Liber, Zagreb 1976, str. 199—218.

[4] Frančula, N.: Osnove automatizacije u kartografiji. Geodetski fakultet Sveučilišta u Zagrebu 1974—76, 53 strane (Umnoženi rukopis).

[5] Jenks, G. F., M. R. Coulson: Clas Intervals for Statistical Maps. U: Internationales Jahrbuch für Kartographie, C. Bertelsman Verlag, Gütersloh 1963, st. 119—133.

[6] UNIVAC Large Scale Systems STAT-PACK, Programmer Reference, Sperry Rand Co 1972.

SUMMARY

In the teaching of cartography at the Geodesy Department of the University of Zagreb they have been using the computer since the school year 1972/73. Available is a UNIVAC 1110 computer of the University Computer Center. The use of a computer in the teaching of mathematical cartography is described in the present article using the example of calculation of rectangular coordinates and deformations in azimuthal projections. In the teaching of cartography, the computer is used also for the preparation of computer thematic maps. For this purpose our own programs KOKART and TESTIR are being used. KOKART is the program for the production of computer maps by the cartogram method, through which statistical data can be classified into 2-10 classes by means of seven methods for the determination of class boundaries. TESTIR is a program for the selection of the most suitable method of determination of class boundaries according to Jenks and Coulson criterion /5/.

NEW ASPECTS OF GEODETIC RECORDING OF UNDERWATER RELIEF

Momčilo ĐORĐEVIC - Belgrade*

The problem of geodetic recording of subwater relief - be it in oceans, seas, lakes, or rivers - has been a problem for many years, in particular for the requirements which demanded precision data. While discovering the possibility that the phenomenon of reflection of emitted sonic energy from the bottom can be used successfully for these recordings, new realizations have been arrived at. The truth is that the phenomenon of sound propagation under water has been known for a long time, and it was in 1804 that it was proposed by the French physicist Dominique Francois Jean Arago that this phenomenon also be used for the recording of underwater relief or for the depth measurements, respectively. Since that time there have been many attempts at realization of this idea, whereas it is at the start of this century that an instrument for depth measurements has been built for the first time using reflection of emitted sonic energy from the bottom, called "echolot." However, all the way until 1930 these instruments had a limited applicability. Depths under 20 m could be measured only by specially trained experts, and the greatest depths which could be measured amounted to approximately 500 m. Here, the most important part for the designation of the receipt of the echo reflected from the bottom was a small neon tube which lit up in red light at the instant that the echo itself is received.

Prior to World War II there existed apparatus capable of continuous registration of the echo by a special scribe. However, since the war,

---

*Author's address: Momčilo Đorđević, MS in engineering - Institute for Navigable Waterways - Francuska 9, Belgrade.

a new method has been developed whereby a thin layer applied to black paper is burnt electrically, thereby accurately recording the instant the echo was received. An important moment has also been the transition to ultrasound, which has principally been done in the period from 1930 to 1940. It is exactly this way that it was made possible to direct a narrow beam of sonic energy vertically toward the bottom, which enabled the obtention of much more accurate data regarding depths measured. Besides this, there is being used recently only one sonic oscillator which is used also for the emitting of the sonic pulse as well as for the reception of the reflected pulse in the form of an echo.

In case of all these instruments called by the general name "echolot", the frequency of 30 kHz is employed the most frequently with the wavelength in water which amounts to 5 cm. Naturally, different requirements are expected of such instruments, above all in the range and depth dependency which must be measured. Thus, for instance, instruments which use a frequency of 30 kHz - which is within the region of medium-high frequencies - are capable of measurements also up to 6000 m. For this reason, lower frequencies, such as 10 or 15 kHz, are used more rarely for instruments intended for measurements in oceans and seas, whereby the usual transmitter effects are 1-5 kW. In addition, for accurate measurements of the depth, one must know accurately the rate of propagation of sound in water. At the international level, an agreement has been reached to implement a sonic velocity of 1500 m/sec for instruments of the "echolot" type. The necessary correction for the adopted rate can be done by using the accurate value of the rate of propagation of sound, which can be determined upon each measurement, or by the use of international tables or graphs from which the probable sound velocity at the given time and in the given region can be determined.

By employing tables and graphs one cannot expect to obtain extremely accurate data for the actual sound velocity and it is also difficult to measure the sound velocity with the purpose of obtaining satisfactory accuracy. It is true that the arrangement of the sound velocity value along the vertical from the ship to the bottom is known, however by this one does not as yet know which average value should be adopted. Therefore it is considered that the results at even the most careful measurement are inaccurate by approximately $\pm$ 1%. However, this inaccuracy can be disregarded, taking into account the measurements as a whole. Thus, for instance, it is considered that it makes no sense to drive out absolute accuracies in individual measurements when it is known that voids exist between individual recorded profiles. On the other hand, of great practical value from the point of view of accuracy is the necessary constant operation of the driving parts of the instruments, in particular the rate of motion of the recording needle. In addition, a highly sensitive sonic oscillator is also necessary, to which requirements there at once attaches itself the need for stabilization of the keenness of the direction of the sonic beam into the direction that is vertical toward the bottom. This direction keenness can by all means be created easier by the application of high frequencies rather than low ones since, for instance, for a keenness of 1° the diameter of the circular surface of the sonic beam must be approximately 20 wavelengths of the sonic frequency used. Thus, at the frequency of 200 kHz it amounts to approximately 15 cm, at the frequency of 30 kHz it amounts to approximately 1 m, and at the frequency of 10 kHz it amounts to approximately 3 m. It must also be mentioned that in the case of the requirement the the sonic beam be completely vertical, the sonic oscillator must be be hung in a shaft or must be forcedly stabilized.

For measurements in lakes, one does not have to take into account all these elements nor to such a high degree of accuracy inasmuch as one has to do with smaller depths and that the distance between the profiles is considerably smaller. In each case before starting the work one should use a control metal plate and one must attune the instrument depending on the rate of propagation of sound which in turn depends on the region in which the measurements are done. For this purpose one uses the practice of stopping the ship in the middle of the region where the measurements are done, whereupon one lowers into water under the ship the metal plate which must be held in a horizontal fashion by means of thin graduated cords. This plate must be lowered to the specific known depth, whereupon one gradually extracts the decreasing depths. The echogram must thereby show graduated differences in the depth expressed in meters. If the number of revolutions of the electric motor is accurately adjusted, the echo traces on the echogram shall be accurately designated on lines designating the whole meters on the echogram. On the other hand, one must adjust the rate of operation of the electric motor in such a way that the above condition is fulfilled.

At the present time, all "echolot" instruments operate by using only a single oscillator both as the transmitter and the receiver of the sound. This has great advantages for depth measurements since by the use of two oscillators - due to their distance between them - there occur differences in the depths which are particularly expressed in case of small depths. One must keep in mind that oscillators used as "echolot" instruments in actuality emit one single beam of sonic energy toward the bottom and this in the conical form, whereby one can by the proper selection of the surface from which emitting takes place, effect also the magnitude of the opening of the angle of this

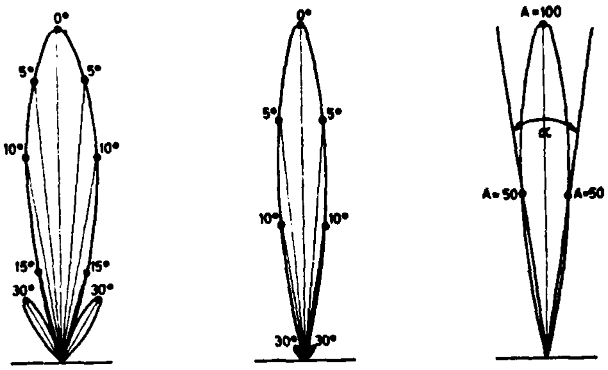


Figure 1.

cone. The higher the surface which is emitting and the higher the frequency the smaller is the magnitude of the opening of the cone. Figure 1 shows the diagrams of the usual circular surfaces from which emitting takes place. At the left is shown the characteristics of a single oscillator, and if the same oscillator is used both for the emitting and for the reception, then its characteristics must be sharper, as shown in the center diagram of Figure 1.

It is obvious that on this diagram the so-called maxima from the side are almost insignificant in comparison with the first diagram. Generally, the opening of the cone of the sonic beam is designated by the angular data of the cone proper and this in the receiving amplitude taking into account also the emitting and the reception as this is shown on the right diagram of Figure 1. However, this principle does not apply to all "echolots" of the instruments, which is care must be exercised when using the possible data on the cone proper. The direction keenness of the sonic beam is particularly important during the requirements for precision measurements as well as in depth measurements if the beaches are steep.

At such measurements the depths cannot be accurately recorded to the bottom proper inasmuch as it is the first contact of the part of the circular surface of the emitted sonic cone with the steep shore that is recorded first. The errors which may appear during such measurements are the smaller the smaller is the magnitude of the opening of the cone angle. Therefore it is also necessary that special attention is devoted to the direction keenness of the sonic beam. Thus, for instance, if one must measure depths to 200 m, it is recommended that sonic frequency of approximately 200 kHz is used, which then makes possible a direction keenness of approximately 1°.

In rivers, longitudinal or transverse profiles are taken mainly, which are then processed in the office. The taking of long longitudinal profile in all cases increases the efficiency of the work, however the taking of transverse profiles provides a greater accuracy. Of course, one strives during this to have the longitudinal and the transverse profiles as close to one another as possible for the sake of obtaining as good as possible overview of the river bed or for as good as possible presentation of the relief of the river bottom. In those sections where greater changes in river bed are expected, the profiles are taken at smaller intervals such that these intervals can also be larger on those sections of the river where river bottom and the bed are stable.

In the processing of the profiles taken in this way one strives to create a combined picture of river bottom, without voids, and if there are voids between individual profiles, then these are filled in by interpolation. Of course, such interpolation - in particular, between profiles which are taken at greater distances between them - will affect the accuracy. This is also why one strives to have the voids between the profiles as small as possible, which in turn requires a larger number of profiles. It is understandable that this also

increases the requirements for greater engageability of the floating object with which this taking is done and likewise in the personnel in the office which processes the terrain data. For this reason, an optimal number of profiles or a tolerable limit, respectively, is sought which is as a matter-of-fact still far from the goal which is the connection between the profiles taken. The unavoidable voids between the profiles are indeed a great weakness during the takings, in particular when control recording is taken of the state of waterways which acquires an even greater expression during the requirements for increased size, especially displacement of the ships which are in operation. The necessary depths which must be guaranteed in waterways are always an imperative requirement of waterways traffic so much so that the requirement for an irreproachable control of the state of the waterways is at an ever increasing high.

The longitudinal and the transverse profiles are taken with different instruments built in at the respective floating objects. During these recordings - in case of transverse profiles - the floating object moves from one shore toward the other, whereby the captain's job is to keep a definite direction of the profile proper. The direction of the profile is generally created by means of two signals placed on each shore (signals for covered direction) and their position - for the sake of further processing - must be such that it is defined in the horizontal and the vertical sense. The most frequently desirable is that the final points of the profile be included in the corresponding geodetic network so that there is no problem thereby in the determination of the coordinates and the angles.

Insofar as the taking of the profile itself is concerned, or the recording of the depth, respectively, the conventional "echograph" can also be used. Here the sonic pulses are created through special

contacts in a single indicator device which again through a condenser arrives to the sonic transmitter--oscillator. It is through it that short sonic pulses are emitted which propagate vertically - in the form of a cone - through the water toward the bottom. One part of this emitted sonic energy is reflected from the bottom and arrives as echo to the sonic receiver where it converts into electrical voltage. After the corresponding amplification, the voltage reaches the metallic needle - scribe - which on special paper records the instants when the echo arrives, by short vertical hyphens (small lines). These hyphens then arrange themselves in such a way that they form a line which represents the bottom through which the floating object has passed and on which the "echograph" is mounted.

However, for instruments of this kind the question of accurate position of the recorded depths relative to the shores and likewise the dimensions of the recording is an ever present one, inasmuch as the recording is done on paper which moves independently of the rate of motion of the floating object. A significant amelioration with respect to conventional "echographs" is created by the use of an instrument called an "echolog" which actually consists of two instruments: an "echograph" for depth measurements, and a "radiolog" for distance measurements. The principle of depth measurements is as has been described, however the distance from the shore is also measured here electromagnetically, based on continuous arrangement of phases. For this purpose are used electromagnetic waves from the high-frequency radio waves region of the order of 34.3 MHz.

By a specially developed and applied method using the corresponding servomotor the paper for the recording is being transported at a rate which is dependent on the rate of motion of the floating object along the profile which is being taken. The magnitude of the distance from

the shore - in addition to what can be read off from the dial - is recorded automatically and on the paper which it is recorded the depth also is graphically recorded in the form of vertical lines automatically obtained every 10 meters. The maximal range of the instrument for the measurement of the distance at the necessary optical visibility is 6 km.

By providing synchronized operation of the instrument for depth measurements and for the measurement of the distances, one obtains entirely automatically a graphical representation of the actual depths along the profile of the so-called "echograms" in the proper corresponding dimensions, so that it can from that instant be used for further processing.

However, during such takings there appears the aforementioned shortcoming as expressed by the voids between the profiles and the necessary interpolation to obtain a whole which may not always correspond to the actual state of the river bottom. This occurs, in particular, if one also interpolates between the points of the neighboring profiles, which neglects the actual state of the river bottom between the profiles taken. As an obvious example one should cite the sandy objects on river bottom (similar to desert dunes) which due to the effect of the river flow move along the direction of the water flow, which however cannot often be recorded by the taking of individual transverse profiles. Likewise, one can rightfully presuppose also that there is a walled ridge or an individual wall between the profiles taken whose position cannot be recorded since the transverse profiles are taken below and above the mentioned underwater object.

The problem cited can successfully be resolved by the use of a special instrument which is called the device for the drawing out

of the river bottom. This device is schematically identical to an "echolog," with the exception that instead of a single oscillator there are used several oscillators in series. During the taking these oscillators must be in a straight line which is directed at the direction of motion of the floating object upon which they are built-in. The integration of the oscillators proper depends on the type of the floating object, whereby two fundamental types can be distinguished. In case of small floating objects the oscillators are built into special levers (Fig. 2) which are present in the object in the contracted state in a way parallel to the symmetry line of the ship. During the taking, these levers are most often rectified pneumatically, taken in or taken out, and are positioned perpendicularly to the symmetry line of the ship in such a way that they are located at a depth of 30-40 cm under the water surface.

In the case of the other shapes, the oscillators are placed along the ship proper, i.e. parallel to the symmetry line of the ship (Fig. 3) and in this case the floating object must during the taking move transversely with respect to the symmetry of the ship. In such a case of built-in oscillators a special type of driving power of the floating object must be provided, this being the most often by the use of Voith-Schneider propellers.

Figure 2.

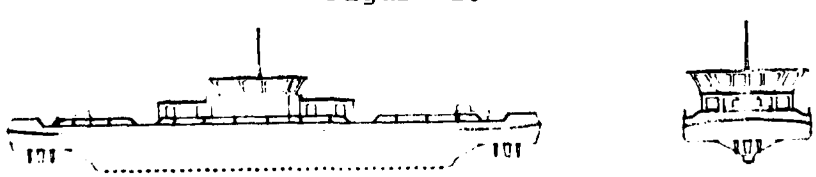


Figure 3.

Using such a way of building in the oscillators one can build in maximally 41 oscillators in such a way that they are by 1 m apart, so that the width of the band which can be taken in one take amounts to 40 meters. For special needs - in particular, if a certain depth is that is required and is guaranteed in the waterway is small - it is desirable that the oscillators are at as short an interval apart as possible. In case of such devices the depths are automatically converted into shaded surfaces whose intensities differ and in such a way that the smaller depths are shaded more intensely with respect to the larger depths which are shaded more brightly. Thus results an echogram on which the shaded surfaces give data on the depths within the band which is, for instance, 40 meters wide. Generally speaking, there are five stages in the intensity of the shadedness: black, dark-gray, medium-gray, light-gray, and white, with the boundary lines between these five stages being very sharp. These boundary lines of the shadedness of various intensities correspond with a high degree of accuracy (± 5 cm) to the specific depth lines which can prior to the taking be as required selected within specific boundaries. Thus, Fig. 4 shows an echogram taken by the Finnish ship "Särkha" whereby the width of the band was 36 meters and the necessary depth which was guaranteed was 10 meters.

The device used with the same program simultaneously gives two tracings with a different degree of spacing between the depth lines. At the bottom part of the echogram the depths are recorded in coarse degrees of the depths which are larger than the necessary guaranteed depth of 10 meters whereby the difference in the depths, from line to line, amounts to 3 meters, so that the represented depths are 10, 13, 16, and 19 meters. On the upper part of the echogram the

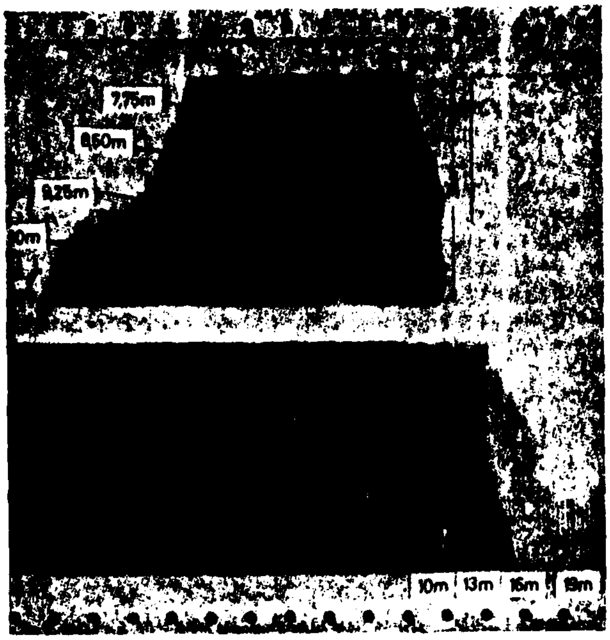


Figure 4.

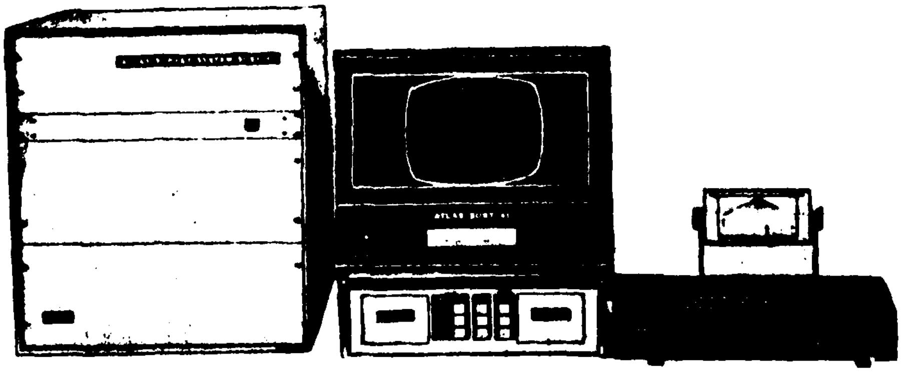


Figure 5.

the depths are recorded by fine degrees of depths, but which are smaller than the necessary guaranteed depth of 10 meters, whereby the difference in the depth from line to line amounts to 0.75 meters, so that the depths shown are 10, 9.25, 8.50, and 7.75 meters.

In this way, during one passage of the ship a band 36 meters in width can be taken and depths both larger and smaller than the guaranteed depth are presented, with the guaranteed depth in the given case being 10 meters. The dimensions of such echograms are such that they are accurate since the rate at which the paper is being transported for the recording is guided by a special part of the instrument which determines the course of the ship with respect to the bottom (not with respect to the water). Additional devices make it possible to automatically convert the depths into values which the instrument cannot remember. This way it is possible to instantaneously transfer the tapes (magnetic or bored) with the recorded data to computer centers where they are processed various ways depending on need.

However, the idea that the activity of the people can be replaced by automatons has been pursued even further. Thus, the Krupp Atlas Electronics firm from Bremen constructed a system called "Susy" 10, and just this year a new automatic system called "Susy" 41 (Figure 5). This is a completely automatized system, by the use of which one can successfully solve many problems during geodetic takings for the purpose of determining underwater relief of oceans, seas, lakes, or rivers.

This new system offers tremendous possibilities in the application inasmuch as among other things it also has various standard inter-units, and it uses the programming language DATRAN (which is comparable to the programming language BASIC) also for the reception of data. The system "Susy" 41 is suitable for the reception of data, taking of data, navigation, and subsequent processing of the data. The contemporary intensive development of individual sensors for this system (such as, for instance, "Deso" for the taking of depths, "Dolog" for

the measurement of the distances, "Edig" for digital display of the depths measured, "Dira" for digital display of the distance, "Boma" for mapping of data, "Lara" for laser measurement of the distance, etc) and their inclusion into the operation of the system "Susy" 41, together with an electronic computer and the other apparatus of the system, makes possible the successful solution of all geodetic problems within the framework of hydrographic requirements of today. The special flexibility of the system for the adaptation to individual sensors has been successfully resolved by the use of inter-unit structure which can very easily be modified. It includes a complete set of standard computer inter-unit modules as well as inter-unit adapters with the possibility of additional cabling. Insofar as the reception of data is concerned from the sensor, it behaves asynchronically, so that sensor data are taken as soon as they are present. In this way the system itself controls the sensors, and not vice versa.

Finally, one should emphasize that during the development of this new system one had in mind, among other things, also the simple and easy handling, as well as the possibility of eventual corrections by the application of the corresponding test programs for the detection of damages and faults, including here also from the side of personnel who have no particular knowledge of electronics and programming. In each and every case the application of the new system "Susy" 41 makes possible successful obtention of optimal results from people, equipment, and capacity of the floating object while availing oneself of the most modern technology.

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION	MICROFICHE
A205 DMATC	1
A210 DMAAC	2
B344 DIA/RDS-3C	9
C043 USAMIIA	1
C509 BALLISTIC RES LABS	1
C510 AIR MOBILITY R&D LAB/FIO	1
C513 PICATINNY ARSENAL	1
C535 AVIATION SYS COMD	1
C591 FSTC	5
C619 MIA REDSTONE	1
D008 NISC	1
H300 USAICE (USAREUR)	1
P005 DOE	1
P050 CIA/CRB/ADD/SD	2
NAVORDSTA (50L)	1
NASA/NST-44	1
AFIT/LD	1
LLL/Code L-389	1
NSA/1213/TDL	2

ORGANIZATION	MICROFICHE
E053 AF/INAKA	1
E017 AF/RDXTR-W	1
E403 AFSC/INA	1
E404 AEDC	1
E408 AFWL	1
E410 ADTC	1
FTD	
CCN	1
ASD/FTD/NIIS	3
NIA/PHS	1
NIIS	2